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Hewlett-Packard Desktop Computer System

HP 98035A Real Time Clock Programming Techniques



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98035A
Real Time Clock
Programming Techniques



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Chapter 1
Clock Operations

Introduction

The Hewlett-Packard 98035A Real Time Clock is an easy to use interface that adds a wide variety of functions and capabilities to your HP desktop computer. The I/O ROM must be present for operation of the Real Time Clock.

With the 98035A, data read from an external device can be printed or stored with the date and time of the reading, and single or multiple interrupts can be generated at accurately timed intervals. The millisecond resolution of the Real Time Clock makes it useful as a timer of computer tasks and a precision alarm clock. The Option 100 cable provides four input lines which can time external events and five output lines to control the device under test.

Programming the Real Time Clock with your desktop computer involves the use of the OUTPUT, ENTER, and READBIN statements. This manual explains the proper use of these statements for some typical tasks. The 98035A Installation and Operation Manual contains a more detailed explanation of the operating characteristics of the Real Time Clock, as well as information on its installation.

What To Do First

Your 98035A Real Time Clock has an internal battery to keep the clock running when the computer is turned off. This battery is charged automatically when the clock is plugged into the computer and the computer is turned on. If the clock has been unused for a long time, this battery may be discharged. When you first turn on your Real Time Clock, follow the procedure listed below.

1. Turn off power to the desktop computer.
2. Plug in the Real Time Clock. (Set the select code to 9*)
3. Turn on computer power.
4. Wait two minutes.
5. Set the time (format for Option 001 shown below).
   Type in:

   ```
   OUTPUT 9;"S mo, da, hr, mn, sc"
   ```
   (EXECUTE)

   mo = 2 digit month number
   da = 2 digit date
   hr = 2 digit hour (24 hr. format)
   mn = 2 digit minute
   sc = 2 digit second

   Example:

   ```
   OUTPUT 9;"S08 27 14 30 00"
   ```

   Same information ordered for Option 002:

   ```
   OUTPUT 9;"S27 08 14 30 00"
   ```
6. If the "run light" stays on, press RESET and wait fifteen minutes so that the clock's internal battery can begin recharging.
7. Repeat step 5.
8. If the "run light" stays on, carefully check that you have performed this procedure properly.
9. If the trouble persists, contact the HP Sales and Service Office nearest you.

* factory setting

Real Time Information

Set Real Time

There are two typical methods for setting the Real Time Clock. The date and time may be sent as a group of numeric variables or as string data. Numeric variables may be output in the correct format as follows:



U.S. Format (Option 001)

```
10 OUTPUT 9 USING "A,5(2Z)";"S",Month,Day,Hour,Min,Sec
```

or

European Format (Option 002)

```
20 OUTPUT 9 USING "A,5(2Z)";"S",Day,Month,Hour,Min,Sec
```

The image specifier establishes an output of a single ASCII character ("S") followed by five two-digit variables with leading zeros and no decimal points. This statement automatically sends a linefeed delimiter after the data list.

A string expression may be used to set the clock with a simple output statement.

```
30  OUTPUT 9;"S 06 09 04 10 00"
```

or

```
10  T$="0609041000"
 •
 •
 •
40  OUTPUT 9;"S",T$
```

Request Real Time

Before any data can be input from the Real Time Clock, an instruction must be sent to the clock to request the desired data. The request instruction for obtaining the time of day is an upper-case "R". Note that lowercase letters in an instruction are ignored by the clock.

```
50  OUTPUT 9;"Request time"
```

or

```
60  OUTPUT 9;"R"
```

After the request is made, the time data may be input. The data can be entered into a string or a series of variables. The variables or the string are then available for further processing or display. The following statements show typical methods of reading the real time after an "R" instruction.

```
70  ENTER 9;T$
```

or

```
80  ENTER 9;Month,Day,Hour,Minute,Second
```

Timing Units

The Real Time Clock has four timing units that can be used either as millisecond counters or as interrupt generators, depending upon the definitions provided by the program. A unit defined as a counter (for example, U3 = I3) counts millisecond intervals (standard clocks) or the number of milliseconds that an external event is true (Option 100 clocks). A unit defined for interrupt operation (for example, U4 = O4) can interrupt your desktop computer at either a specified day and time, a specified periodic interval, or a combination of match time, delay and periodic interval. The following sections describe these functions in more detail.

A timing unit can be in one of two states: active (ON) or halted (OFF). This is true whether the unit is assigned to an input or an output. In general, a unit must be in the active state to perform its desired function (interrupting or counting), and must be in the halted state to accept new parameters. For detailed information about timing units, unit states, and unit assignments, refer to the 98035A Installation and Operation manual.

The term "input" is used to refer to a unit counting milliseconds, and the term "output" is used to refer to a unit generating interrupts. To select unit one for interrupt operation (output) and unit three for counting operation (input), the following instruction can be sent to the Real Time Clock:

```
100  OUTPUT 9;"Unit1=Output1 Unit3=Input2"
```

or

```
110  OUTPUT 9;"U1=O1 U3=I2"
```

NOTE

A timing unit must be in the halt state before it will accept a unit definition instruction.

The exact program sequence used to define a unit depends upon the current state of that unit and the current activity of the other units. Any halted or unassigned unit can be defined by simply sending it a definition instruction. An active unit must first be halted before it can be redefined. Any assigned or unassigned unit can be halted with an "A" instruction. However, the "A" instruction will halt all the other units and disable interrupts. Any assigned unit can be halted with a "Halt Selected Unit" instruction ("H") without disturbing any other unit or operation. However, the "H" instruction cannot be executed on an unassigned unit without generating an error. By considering the state of the clock when a unit definition is needed, you can determine if a halt instruction is required, and if so, which type of halt should be used. Different approaches will be represented in the forthcoming example programs.

NOTE

When the Real Time Clock is initialized by a power-on, a system reset, or a "B" instruction, unit 1 is automatically assigned to output port 1, and unit 2 is automatically assigned to input port 1. These ports cannot be assigned to another unit unless they are first undefined. (see "Program Debugging Hints", Problem #1).

Unit State Control

Individual units can be started and stopped when desired. The instructions to accomplish this require a particular timing unit to be selected, as shown in the following examples.

Activate Selected Unit

```
120  OUTPUT 9;"Unit 1 Go"
```

or

```
130  OUTPUT 9;"U1G"
```

Halt Selected Unit

```
140  OUTPUT 9;"Unit 1 Halt"
```

or

```
150  OUTPUT 9;"U1H"
```

In those cases where it is desirable to operate all units simultaneously, two instructions for synchronous start and stop of the timing units are given. The "A" and "F" instructions affect all timing units regardless of the current state of the unit or its operating mode.

Activate All Units

```
160  OUTPUT 9;"Fire all units"
```

or

```
170  OUTPUT 9;"F"
```

Halt All Units

```
180  OUTPUT 9;"All units halt"
```

or

```
190  OUTPUT 9;"A"
```

Interrupt Instructions

The 98035A has three types of interrupt instructions, allowing a flexible interrupt sequence to be established. The Match instruction is like an alarm clock, providing a single interrupt at a preset time. The Period instruction generates a continuing stream of interrupts at regular intervals. A Delay instruction is also available for simple time delay generation. These three instructions can be used individually or in various combinations which allow you to tailor the interrupt output of the clock to suit your specific application. For added control flexibility, Option 100 clocks provide an external pulse output coincident with any interrupts so that external devices can also be signaled by the clock.

NOTE

Your desktop computer can operate on an interrupt basis only if an interrupt service routine is established, a control mask is defined, the Real Time Clock is enabled for interrupts, and the desired clock unit is defined as an output and activated.

Match

The Real Time Clock can generate an interrupt when the real time value equals the match value. The day, hour, minute, and second of a match interrupt can be specified by the match instruction. The match instruction can be sent to the Real Time Clock by the following statements:

```
200 OUTPUT 9 USING "3A,4(2Z)";"U1M",Day,Hour,Minute,Sec
```

or

```
210 OUTPUT 9;"U1M 06 05 10 00"
```



or

```
220 OUTPUT 9;"Unit 1 Match at 06day,05hours,10min,00sec"
```

The match value must be an even number of digits. If fewer than the maximum number of digits are to be sent, the Real Time Clock builds the match from the right — for example:

```
230  OUTPUT 9;"U1M 100500/U1G"
```

This will give a match interrupt at 10:05 a.m.

Delay

A match interrupt can be delayed by sending a delay instruction to the Real Time Clock. If a delay instruction is used without a match, the delay time is measured from the time the unit is activated. Delays from a millisecond to more than a day can be generated using this instruction.

The delay instruction can be sent by an OUTPUT statement specifying the number of milliseconds of delay, such as:

```
240  OUTPUT 9;"U1D 1000"
```

or

```
250  OUTPUT 9;"Unit 1 Delay 1000ms then interrupt"
```

If a delay instruction is sent to a timing unit defined to match, then the timing unit delays the match interrupt for the number of milliseconds specified by the delay instruction. For example, the following program sequence will delay a match interrupt for fifteen minutes if a flag has been set.

```
260  OUTPUT 9; "Unit 4 = Output 4 Unit 4 Match 121500"
270  IF Flag THEN OUTPUT 9; "Unit 4 Delay 900000 ms"
280  OUTPUT 9; "Unit 4 Go"
```

Line 260 sets up a match on unit four. This line assumes that unit four is unassigned, so the definition is sent without a halt.

Line 270 checks a flag. If it is set, unit four is additionally programmed for a fifteen minute delay (900000 milliseconds).

Line 280 activates the unit.

Period

A periodic mode can be established in the Real Time Clock to provide interrupts on a continuing periodic basis. This mode is programmed into a unit as follows:

```
290  OUTPUT 9;"Unit 4 interrupt  Period is 12345 ms"
```

or

```
300  OUTPUT 9;"U4P12345"
```

The next example shows a sixty second periodic interrupt providing an accurate timing interval for a measurement or test, such as with a system voltmeter. This interrupt also increments a counter which is used to provide a specific number of I/O operations.

```
100       ON INT #9 GOSUB Irq              ! Establish service routine
110       CONTROL MASK 9;128               ! Interrupt enable mask
120       CARD ENABLE 9                    ! Enable interrupts
130  !
140  OUTPUT 9;"Unit2Halt,Unit2=Output2,Unit2Period 60.000sec/Unit2Go"
150  !
160  !                Your program goes here.
170  !
180  !
400 Irq:  OUTPUT 9;"T";                   ! Request trigger code
410  Source=READBIN(9)                    ! Read trigger code
420  CARD ENABLE 9                        ! Reenable interrupts
430  IF NOT BIT(Source,1) THEN RETURN     ! Service unit 1 interrupts only
440  GOSUB Measure                        ! Execute user's routine
450  Counter=Counter+1                    ! Increment counter
460  RETURN
470  !
480 Measure:                              ! Your subroutine goes here
490  ! This subroutine obtains the data from your peripheral device.
500  RETURN
```

Line 140 establishes a periodic mode on unit two. This line assumes that unit two had been previously assigned as an input, but its current state is unknown. Therefore, it is first halted using a "U2H" instruction. Next it is redefined as an output unit, given a period of 60000 milliseconds, and activated.

The advantage of this approach is that the main program is not "tied up" waiting for and counting each measurement or reading. The interrupt routine controls the data gathering while the main program simply monitors the variable "Counter" as it goes about its other business.

NOTE

Depending upon the amount of processing being done in the main program and the interrupt routine, your desktop computer may not be able to process periodic interrupts from the Real Time Clock occurring more closely together than eighty milliseconds. A Real Time Clock interrupt might also be missed if three or four units are defined as outputs and they generate interrupts too close to one another.

Counting Milliseconds

Defining a unit to the counting mode is an alternative to the interrupt mode previously discussed. When in the counting mode, a unit can time events with millisecond accuracy and a range from milliseconds to months. The action of counting units is controlled by the program and, for Option 100, the external input lines.

NOTE

A unit will only function as a timer if its input line is "true", and it is defined as an input and activated. The input lines on standard clocks are always "true". The input lines on Option 100 clocks need to be grounded or "low" to make them "true".

Request Value

The request instruction for obtaining the current millisecond value of a counting unit is an uppercase "V".

```
350  OUTPUT 9;"Unit 2 Value request"
```

or

```
360  OUTPUT 9;"U2V"
```

After the request is made, the time data may be input. The following example displays the current value in seconds of timing unit three.

```
370  OUTPUT 9;"Unit3Value"
380  ENTER 9;Millisec
390  DISP Millisec/1000;"seconds"
```

Unit Clear

To clear a particular counting unit to zero, a unit clear may be output to the Real Time Clock, such as:

```
400  OUTPUT 9;"Unit 2 Clear counter"
```

or

```
410  OUTPUT 9;"U2C"
```

Status and Control Instructions

The Real Time Clock returns several status words indicating existing error conditions, which timing unit(s) interrupted, or any presently unserviced interrupt(s). The status and control bit descriptions are listed in the Appendix.

Error Code

To read the Real Time Clock error code, a request/input sequence is executed, as shown below:

```
420  OUTPUT 9;"Error check"
430  Error_code=READBIN(9)
```

The value of the variable `Error_code` can be analyzed using the "bit" function. A typical analysis is shown in the "Utility Programs" chapter. An explanation of the error codes is included in the Appendix.

Trigger Code

Although the computer automatically recognizes the select code of an interrupt request, it will not automatically identify which timing unit inside the Real Time Clock generated that interrupt. When more than one timing unit is operated in the interrupt mode, it is desirable to determine the exact source of an interrupt so that the correct response can be made. This is done by requesting the trigger code.

The sequence of operations to obtain the trigger code is similar to the error code sequence.

```
440  OUTPUT 9;"Trigger check"
450  Trigger_line=READBIN(9)
```

When speed is an important consideration, the comment form of clock instruction should be avoided. Output speed can be increased significantly by using only the single letter instruction and a formatted output. Although the Real Time Clock requires a delimiter for time data, it does not need any delimiter after the simple alphabetic instructions. The statement below sends one ASCII "T" with no blanks, no carriage return, and no linefeed. Therefore, this format produces the fastest transfer from your desktop computer to the Real Time Clock.

```
470  OUTPUT 9 USING "#,A";"T"
```

Note that the trigger code corresponds to an output port number, not a unit number. If bit 0 of the trigger code is set, then the unit assigned to output port 1 generated the interrupt. This may or may not be unit 1, depending upon the assignments you have made in your program. The trigger codes and corresponding output ports are listed in the Appendix.

Unserviced Interrupt Code

After an interrupt request is serviced, the Real Time Clock is automatically disabled for further interrupts. The interrupt service routine must re-enable the interface before any other interrupts can be processed. If a timing unit attempts to generate an interrupt before the interface is reenabled, the event is logged as an "unserviced interrupt". (Refer to the 98035A Installation and Operation Manual for further information about unserviced interrupts.)

The unserviced interrupt code is requested with a "W". It is interpreted the same as the trigger code discussed in the preceding section. The bits show which output port(s) requested the unserviced interrupt. One sequence for obtaining the unserviced interrupt code is shown below.

```
480  OUTPUT 9;"W";
490  Missed_int=READBIN(9)
```

Bypass Self Test

The "B" instruction causes the Real Time Clock to initialize to a power-on state without executing the self-tests. It can be sent as follows:

```
500  OUTPUT 9;"Bypass self test and initialize"
```

or

```
510  OUTPUT 9;"B"
```

After receiving the "B" instruction all units are placed in the halt mode, all registers are cleared, unit 1 is defined to output port 1, unit 2 is defined to input port 1, and the clock is disabled for interrupts.

Interface Status

The Real Time Clock, like the 98032A, has nine interface status bits which can be monitored using the interface status statement. The following example checks the status code for an error indication.

```
520  STATUS 9;Stat
530  IF BIT(Stat,0) THEN GOTO Error
```

A summary of the status bits is listed in Appendix B. For more detailed information concerning the interface status word, refer to the 98035A Installation and Operation Manual.

Chapter 2
Option 100 Cable Operations

Introduction

Option 100 for the Real Time Clock provides four input lines and four output lines, plus a SYNC output. These lines allow the clock to time and control external events. Information about the electrical characteristics of these lines is available in the 98035A Installation and Operation Manual. You should be familiar with these electrical characteristics before attempting to connect any device to the Real Time Clock.

Read External Input Lines

The Real Time Clock returns the current state of the external input lines in response to the "N" instruction. The external lines can be read as follows:

```
100  OUTPUT 9;"read iNputs"
110  Inputs=READBIN(9)
```

Each of the first four bits of the resulting variable corresponds to one of the input lines. A bit is set when the input line is "true" (low) at the time of the reading. If the "N" instruction is preceded by an "L" definition, output lines will be pulsed at the time of the input reading (see next section). The SYNC line is always pulsed by an "N" instruction.

Pulse External Output Lines

There are two conditions that will cause a 4 ms pulse on an output line of the Option 100 cable. One condition is when the timing unit assigned to that output port generates an interrupt. The other condition is when that output line has been enabled by an "L" instruction, and the clock receives an "N" instruction. This section refers to the second case.

The output lines are enabled by the lower four bits of a "mask" which is sent in the "L" instruction sequence. The following example shows a descriptive way of enabling output lines #3 and #4.

```
120  Bit=2
130  Mask=Bit^2+Bit^3
140  OUTPUT 9 USING "2A,B";"L/";Mask
```

In this example, the bits to be enabled correspond to the power of two used in building the variable Mask. All following "N" instructions pulse the lines previously defined by the "L" instruction. Since only four output lines are available on the real time interface, only values corresponding to bits 0-3 are used by the clock. The correspondence is shown below:

Bit Position	Output Line Number	Bit Value	Decimal Value
Bit 0	Output 1	send 2∧0	1
Bit 1	Output 2	send 2∧1	2
Bit 2	Output 3	send 2∧2	4
Bit 3	Output 4	send 2∧3	8

The following sequence shows another method of specifying which output lines are to be pulsed by calculating the value before sending out the line specification byte. The example enables and pulses all four output lines.

```
150  OUTPUT 9 USING "2A,B,A";"L/";15;"N"
```

Chapter 3
Utility Programs



Introduction

The following programs are provided to help you program your desktop computer for the Real Time Clock. They are written as subroutines that can be appended to your main programs. These subroutines are only suggestions of possible utilities. They can be easily altered and optimized to suit your particular application.

Set Real Time Subroutine

This subroutine requests a two-digit value for each variable to be set; the current month, date, hour, minute and second. The input data is then assembled into the proper format for the Real Time Clock, then output.

```
100  Time$=RPT$(":",14)    ! Puts colons between digits for display purposes
110  LINPUT "Do you want to set the real time clock?",In$
120  IF UPC$(In$[1,1])<>"Y" THEN GOTO End          ! Check for "yes" response
130  OUTPUT 16;"Enter each time group as a two-digit number and press CONT."
140  LINPUT "What month? (01 - 12)",Time$[1,2]
150       REM  Use month number to lookup maximum number of days
160       Month=VAL(Time$[1,2])
170       ON Month GOTO One,Feb,One,Zero,One,Zero,One,One,Zero,One,Zero,One
180 One:  LINPUT "What day? (01 TO 31)",Time$[4,5]
190       GOTO Hour
200 Zero: LINPUT "What day? (01 TO 30)",Time$[4,5]
210       GOTO Hour
220 Feb:  LINPUT "What day? (01 TO 29)",Time$[4,5]
230 Hour: LINPUT "What hour? (00 - 23)",Time$[7,8]
240  LINPUT "What minute? (00 - 59)",Time$[10,11]
250  LINPUT "What second? (00 - 59)",Time$[13,14]
260  OUTPUT 9;"hAlt units & Set";Time$          ! Time setting instruction
270  OUTPUT 16;"Time setting initiated at ";Time$
280  OUTPUT 16;"DO NOT RESET OR REMOVE POWER FOR 90 SECONDS"
290  RETURN
300 End: DISP "So be it."
310  RETURN
```

Display Real Time Subroutine

The time can be read into a single string and displayed. This is an extremely simple operation, but the display is just a group of two-digit numbers separated by colons. The appearance of the data can be greatly improved by using some of the available processing power of your desktop computer. The following subroutine uses one of many methods of time display.

Lines 300 through 340 are used to build an array of month names. Since this does not need to be done more than once, it is not necessary for these lines to be processed in every pass through the subroutine. A good alternative is to move lines 280 through 340 to the beginning of your main program. If the DATA statement is read only once during program initialization, the RESTORE statement is not necessary.

Lines 380 through 410 convert the 24-hour format of the clock into a 12-hour, "AM/PM" format. This is optional, of course. A typical display is shown below.

```
AUG 28                    3:58:30 PM
```

```
200  OUTPUT 9;"Request time"                ! Request real time
210  ENTER 9;Month,Day,Hour,Time$           ! Read real time
220  !
230  ! ************************************************************************
240  !  These initializations only need to be executed once. Although they
250  !  will function in this subroutine, it is more efficient to move them
260  !  out of the subroutine and into the beginning of your program.
270  !
280  DIM Month$(12)[5],Mer$[2]              ! Initialize some variables
290  INTEGER Hour
300  RESTORE                                ! Place pointer at start of data
310  FOR I=1 TO 12
320  READ Month$(I)                         ! Read data into string array
330  NEXT I
340  DATA JAN,FEB,MARCH,APRIL,MAY,JUNE,JULY,AUG,SEPT,OCT,NOV,DEC
350  !
360  ! ************************************************************************
370  !
380  Mer$="AM"                              ! Start by assuming "AM"
390  IF Hour>11 THEN Mer$="PM"              ! Use "PM" if past noon
400  IF Hour>12 THEN Hour=Hour-12           ! Convert to 12-hour format
410  IF Hour=0 THEN Hour=12
420  DISP Month$(Month);Day,Hour;"%s";":";Time$;"  ";Mer$
430  RETURN
440  !
```

Set Interrupt Subroutine

This program is a conversational subroutine that asks for data about a desired real time interrupt and outputs the appropriate instruction to establish that interrupt. This routine allows for Match, Delay, or Periodic interrupts, but does not form any combinations. There is a check for periodic intervals less than 100 milliseconds. The processing time for servicing Real Time Clock interrupts closer together than 100 ms limits available program execution time. Periodic interrupts more rapid than this should not be specified except for special applications. Note that an interrupt service routine must be established to suit your need. This example has a "dummy" interrupt service routine at line 480 which can be modified as desired.

```
100  LINPUT "Do you want a real time interrupt?",In$
110  IF UPC$(In$[1,1])<>"Y" THEN GOTO Leave          ! Check for "yes" response
120  ON INT #9 GOSUB Interrupt                       ! Establish service routine
130  CONTROL MASK 9;128                              ! Interrupt enable mask
140  !
150  LINPUT "What type of interrupt? MATCH, DELAY, or PERIOD",In$
160 Check: IF UPC$(In$[1,1])="M" THEN GOTO Match     ! Check for "match" response
170  IF UPC$(In$[1,1])="D" THEN GOTO Delay           ! Check for "delay" response
180  IF UPC$(In$[1,1])="P" THEN GOTO Period          ! Check for "period" response
190  LINPUT "Type in MATCH, DELAY, or PERIOD and press CONT.",In$
200  GOTO Check                                      ! Response not recognized
210  !
220 Match: LINPUT "Enter match time (example: 3:35pm=153500).",In$
230  OUTPUT 9;"B U1M",In$                            ! Set match interrupt
240  GOTO Finish
250  !
260 Delay:  LINPUT "Enter milliseconds of delay.",In$
270  DISP "PRESS CONTINUE TO START DELAY"
280  PAUSE                                           ! Wait for start signal
290  OUTPUT 9;"B U1D",In$                            ! Set delay interrupt
300  GOTO Finish
310  !
320 Period:  LINPUT "Enter desired period in milliseconds.",In$
330  IF VAL(In$)<100 THEN GOTO Short                 ! Interval very short
340  DISP "PRESS CONTINUE TO START PERIODIC INTERRUPTS"
350  PAUSE                                           ! Wait for start signal
360  OUTPUT 9;"B U1P",In$                            ! Set periodic interrupts
370  GOTO Finish
380 Short:  DISP "Interval may be too short for required processing."
390  RETURN
400  !
410 Finish: CARD ENABLE 9                            ! Enable interrupts
420  OUTPUT 9;"U1G"                                  ! Start unit 1
430  DISP "Real time interrupt established."
440  RETURN
450 Leave: DISP "Killjoy!"                           ! Wisecrack from computer
460  RETURN
470  !
480 Interrupt: BEEP                                  ! Your subroutine goes here
490  CARD ENABLE 9                                   ! Reenable interrupts
500  RETURN
```

Error Decoding Subroutine

This subroutine checks the eight bits of the error code returned by the Real Time Clock and prints the appropriate error message. The bits of the variable Err correspond to the error conditions listed under the Error Code description in the Appendix. This routine can be appended to your program and called after sending instructions to the Real Time Clock. It provides an easy means of checking instruction sequence errors, hardware failures, or data errors.

```
300 Error: DISABLE          ! Insure that error code fetch is not interrupted
310        OUTPUT 9 USING "#,A";"E"
320        Err=READBIN(9)
330        ENABLE           ! Interrupts OK now
340   IF NOT Err THEN RETURN          ! No error bits set
350   !
360   !  Check software errors one bit at a time
370   IF NOT BIT(Err,0) THEN GOTO One
380   PRINT "INTERRUPT MISSED"
390 One: IF NOT BIT(Err,1) THEN GOTO Two
400   PRINT "IMPROPER INSTRUCTION SEQUENCE OR DATA OUT OF RANGE"
410 Two:  IF NOT BIT(Err,2) THEN GOTO Three
420   PRINT "INSTRUCTION INCONSISTENT WITH CURRENT UNIT OR PORT ASSIGNMENTS"
430 Three:  IF NOT BIT(Err,3) THEN GOTO Four
440   PRINT "INSTRUCTION NOT ALLOWED WITH ACTIVE UNIT(S)"
450   !
460   !  Hardware errors are split into two general groups
470 Four:  IF NOT BIT(Err,4) THEN GOTO Five
480   PRINT "REAL TIME LOST OR BATTERY LOW"
490 Five:  IF BIT(Err,"000XXXXX") THEN RETURN
500   PRINT "CLOCK HARDWARE DEFECTIVE"
510   RETURN
```

Program Timing

One popular use of the Real Time Clock is the timing of benchmark subroutines and program segments. One way to do this is to define and enable a counter during program initialization. A typical line to accomplish this is shown below:

```
10  OUTPUT 9;"All units halt,Unit1=Input4,Unit1Go"
```

(The initial halt instruction is optional. It is included to ensure that unit 1 is in the proper mode to receive new commands or redefinition.)

Timing a subroutine now involves only clearing the counter, calling the subroutine, then reading the counter, as shown below.

```
100  OUTPUT 9;"Unit 1 Clear"
110  GOSUB Benchmark
120  OUTPUT 9;"Unit 1 Value"
130  ENTER 9;Result
```

The variable Result now contains the millisecond value of the time spent in the subroutine "Benchmark". Note that for critical timing requirements, the comment form of Real Time Clock instructions would not be used, due to the variablility in handshake timing from one reading to the next. For example, the previous program code would be changed to:

```
100  OUTPUT 9 USING "#,3A";"U1C"
110  GOSUB Benchmark
120  OUTPUT 9 USING "#,3A";"U1V"
130  ENTER 9;Result
```

Interrupt Service Routine

The handling of multiple interrupts is one of the most critical programming tasks to undertake when using interrupt operation with the Real Time Clock. It is possible to miss interrupts under certain conditions such as three timing units interrupting the calculator in succession at one millisecond intervals. Your desktop computer cannot service the interrupts fast enough to prevent the loss of an interrupt if successive interrupts occur as close together as one millisecond. The following routine is set up to handle two interrupts occurring closely together (1 millisecond), but it could miss an interrupt if more than two interrupts occurred at an interval closer than 30 milliseconds.

The speed with which multiple interrupts can be serviced depends upon many variables. These include the type of desktop computer, the amount of processing done on the lines in the main program, the amount of processing done in the interrupt service routine, and the time spent in I/O operations. Because of this, it is difficult to make general statements about the maximum speed with which interrupts can be serviced. For optimum performance, keep the main program lines short, the interrupt processing simple, and use formatting that keeps I/O time to a minimum. If you are concerned about the time required for a specific operation, use the Real Time Clock to measure the activity and pick the fastest alternative.

```
100       OVERLAP                          ! Optional OVERLAP mode
110       ON INT #9 GOSUB Irq              ! Establish service routine
120       CONTROL MASK 9;128               ! Interrupt enable mask
130       CARD ENABLE 9                    ! Enable interrupts
140 Irq:  OUTPUT 9 USING "#,A";"T"         ! Request trigger code
150  First=READBIN(9)                      ! Read trigger code
160  CARD ENABLE 9                         ! Reenable interrupts
170  ! Interpret trigger code
180  ON First GOSUB A,B,Syn,C,Syn,Syn,Syn,D,Syn,Syn,Syn,Syn,Syn,Syn,Syn
190  !
200  ! Check for any interrupt that may have occurred during servive routine
210  DISABLE
220  OUTPUT 9 USING "#,A";"W"
230  Second=READBIN(9)
240  ENABLE
250  IF NOT Second THEN RETURN            ! If none, service is complete
260  !  Otherwise, interpret "missed interrupt" code
270  ON Second GOSUB A,B,Syn,C,Syn,Syn,Syn,D,Syn,Syn,Syn,Syn,Syn,Syn,Syn
280  RETURN
290  !
300  !   The following PRINT statements are used to represent the non-trivial
310  !   interrupt service routines that would be used in actual applications.
320  !
330 A: PRINT "Servicing PORT 1 interrupt"
340  RETURN
350 B: PRINT "Servicing PORT 2 interrupt"
360  RETURN
370 C: PRINT "Servicing PORT 3 interrupt"
380  RETURN
390 D: PRINT "Servicing PORT 4 interrupt"
400  RETURN
410 Syn:  PRINT "Synchronous firing; Code=";First,Second
420  RETURN
```

Appendix A

Instruction Set of the 98035A Real Time Clock

The following list is a summary of the 98035A instructions and an example of the BASIC implementation for each instruction.

"#" represents a specific unit or port number (1-4).

Instruction	Description, Example
"A"	Halt All Units `OUTPUT 9;"A"`
"B"	Fast Initialize `OUTPUT 9;"B"`
"C"	Clear Selected Counter `OUTPUT 9;"U#C"`
"D"	Delay Specification* `OUTPUT 9;"U#D9999"`

"E"	Error Code Request
	`OUTPUT 9;"E"`
	`Err=READBIN(9)`

"F"	Activate All Units `OUTPUT 9;"F"`
"G"	Activate Selected Unit `OUTPUT 9;"U#G"`
"H"	Halt Selected Unit `OUTPUT 9;"U#H"`
"I"	Define Selected Unit to Selected Input Port `OUTPUT 9;"U#=I#"`
"J"	Not applicable
"K"	Not Applicable
"L"	Enable Selected External Output Lines `OUTPUT 9 USING "2A,B";"L/",3`

* These instructions require a delimiter after specifying the value and before chaining another instruction. Refer to the note on the following page for clarification.

"M" Real Time Match Specification*

```
OUTPUT 9;"U#M 12 08 16 30"
```

"N" Read External Input Lines

```
OUTPUT 9;"N"
In=READBIN(9)
```

"O" Define Selected Unit to Selected Output Port

```
OUTPUT 9;"U#=O#"
```

"P" Set Periodic Interval*

```
OUTPUT 9;"U#P9999"
```

"Q" Enable Clock Chip Test Point

```
OUTPUT 9;"Q"
```

"R" Read Real Time

```
OUTPUT 9;"R"
ENTER 9;Time$
```

"S" Set Real Time*

```
OUTPUT 9;"S 12 24 20 30 00"
```

"T" Trigger Code Request

```
OUTPUT 9;"T"
Trig=READBIN(9)
```

"U" Unit Selection Specification
(see "C","D","G","H","I","M","O","P","V")

"V" Counter Value Request

```
OUTPUT 9;"U#V"
ENTER 9;Time
```

"W" Missed Interrupt Code Request

```
OUTPUT 9;"W"
Miss=READBIN(9)
```

"X" Deactivate Clock Chip Test Point

```
OUTPUT 9;"X"
```

"Y" Not Applicable

"Z" No Operation

* These instructions require a delimiter after specifying the value and before chaining another instruction. Refer to the note on the following page for clarification.

NOTE

If you are not chaining instructions, and are using the OUTPUT statement to send instructions, the slash delimiter is not necessary. The OUTPUT statement has an inherent linefeed delimiter that is automatically output at the end of a line.

Example:

```
OUTPUT 9;"U3D1500"
```

No extra delimiter




```
OUTPUT 9;"U3D1500/U3G"
```

Delimiter

Appendix B

Status and Control Codes

These code explanations are for quick reference. For a more detailed explanation of these codes, please refer to the 98035A Installation and Operation Manual.

Error Codes

Bit 0-3 —	**Software Errors**
Bit 0 —	Missed interrupt
Bit 1 —	Improper instruction sequence or data out of range
Bit 2 —	Instruction is not consistent with current assignments. (For example, sending a Match instruction to a unit defined as a counter.)
Bit 3 —	Instruction is not allowed for execution with active units
Bits 4-7 —	**Hardware Errors**
Bit 4 —	Real time lost
Bit 5 —	Clock hardware malfunctioning
Bit 6 —	Clock memory error
Bit 7 —	Clock memory error

Trigger Codes

Bits Set	**Source**
Bit 0 —	Output #1 Interrupt
Bit 1 —	Output #2 Interrupt
Bit 2 —	Output #3 Interrupt
Bit 3 —	Output #4 Interrupt
Bits 4-7 —	Always 0

Missed Interrupt Codes

(Same as Trigger Codes)

Direct I/O Codes

Input Codes (returned in response to the "N" instruction)

Bits Set	Source
Bit 0 —	Input Line 1
Bit 1 —	Input Line 2
Bit 2 —	Input Line 3
Bit 3 —	Input Line 4
Bits 4-7 —	Always 0 (only four input lines are available)

Output Codes (Output lines are pulsed after a combination of "L" and "N" instructions)

Bits Set	Destination
Bit 0 —	Output Line 1
Bit 1 —	Output Line 2
Bit 2 —	Output Line 3
Bit 3 —	Output Line 4
Bits 4-7 —	Ignored(only four output lines are available)

Interface Status Codes

Bit 0 —	Error Flag
Bit 1 —	Interrupt Enable Flag
Bits 2-4 —	Always 0
Bit 5 —	Always 1
Bit 6 —	Always 0
Bit 7 —	Interrupt Status
Bit 8 —	Peripheral OK(should be 1)

Appendix C



Program Debugging Hints

This section presents some of the common errors and oversights experienced in the use of the Real Time Clock. If you are having a problem, the following paragraphs may be helpful. Also refer to your I/O ROM Programming manual to check on the proper usage of the I/O statements.

Problem: The clock does not accept a unit assignment to input port 1 or output port 1.

Solution: Units can be assigned and reassigned to any port, provided that the desired port is not already in use. Input port 1 and output port 1 are automatically assigned during initialization. Therefore, these ports are not free when the clock is in the default state. A port can be freed by unassigning the unit which is using it. To free input port 1, send U2=. To free output port 1, send U1=.

Problem: The clock does not accept changes in time specifications during program editing.

Solution: As an example, assume that you have the following statement in a program:

```
OUTPUT 9;"U3=03 U3P2000/U3G"
```

This is a valid instruction and will run properly the first time. Now you stop the program, and edit the statement to:

```
OUTPUT 9;"U3=03 U3P4000/U3G"
```

When you press (RUN) again, the clock will not accept the new instruction. Pressing (STOP) halts program execution, but it has no effect on Real Time Clock timing units. Unit 3 is still in the active state from the first program run. A unit must be halted before its specifications can be changed. One way of doing this is to add an "A" instruction, such as:

```
OUTPUT 9;"A U3=03 U3P4000/U3G"
```

Read the next paragraph for a hint on using "A" with interrupts.

Problem: The clock fails to interrupt, even when a unit is properly assigned and activated.

Solution 1: The Halt All Units instruction ("A") also disables interrupts. The following sequence will **not** produce any interrupts.

```
10   ON INT #9 GOSUB Irq
20   CONTROL MASK 9;128
30   CARD ENABLE 9
40   OUTPUT 9;"A U3=03 U3P4000/U3G"
```

A CARD ENABLE must be sent **after** an "A" instruction if interrupts are desired. The following example shows a proper initialization routine.

```
10   OUTPUT 9;"All stop"
20   ON INT #9 GOSUB Irq
30   CONTROL MASK 9;128
40   CARD ENABLE 9
50   OUTPUT 9;"U3=03 U3P4000/U3G"
```

Solution 2: Although many clock instructions do not require a delimiter, time specifications (data) must be delimited. The following statement is **not** a valid instruction.

```
OUTPUT 9;"U1P60000 U1G"
```

Data can be delimited in either of two ways. One way is to use the computer's inherent linefeed.

```
OUTPUT 9;"U1P60000"
OUTPUT 9;"U1G"
```

The other way is to use a slash as a delimiter.

```
OUTPUT 9;"U1P60000/U1G"
```

Problem: A unit in periodic mode produces one interrupt then stops.

Solution 1: After generating an interrupt, the Real Time Clock is automatically disabled for further interrupts. The interrupt service routine must reenable the interface if further interrupts are desired. The following example shows a service routine that does **not** reenable interrupts properly.

```
100 Irq:! Real time interrupt service routine
110   IF Flag THEN RETURN
120   GOSUB Compute
130   CARD ENABLE 9
140   RETURN
```

Interrupts are reenabled by this return,

but not by this alternate return.

Solution 2: This explanation applies to a unit that is in the "delay + periodic" or "match + periodic" mode. Although the interface must be reenabled after each interrupt, it is not necessary to send any kind of reenabling instruction to a timing unit that is in the periodic mode. The following example shows the incorrect usage of a "G" instruction in an interrupt service routine.

```
100 Irq:! Periodic interrupt service routine
110   GOSUB Compute
120   OUTPUT 9;"Unit 1 Go"
130   CARD ENABLE 9
140   RETURN
```

Sending a "G" or an "F" to a unit defined to "delay + periodic" or "match + periodic" will reset that unit to "delay" or "match". It will begin its entire instruction, and interrupts will not resume until the "delay" or "match" specifications are again met.

Problem: An interrupt from a unit sometimes interferes with another operation, such as reading the time or a counter value.

Solution: Data from the Real Time Clock is obtained using a two-instruction sequence: one to request and one to input. If this sequence is interrupted after the request, but before the input, the request can be overridden. For example, the main routine may be in the process of requesting the real time when the interrupt routine requests the trigger code. The second request will be honored, and the first one lost. When the program returns from the interrupt, the clock will provide only a linefeed for the real time input operation. This situation can be avoided by "framing" the request/input sequence with an interrupt disable. This technique is shown in the following example.

```
100  DISABLE
110  OUTPUT 9;"Read time"
120  ENTER 9;Time$
130  ENABLE
140  DISP Time$
```

Problem: You are using the SET TIMEOUT feature of the I/O ROM, and you get ERROR 163 when attempting a clock operation immediately after a time set instruction or a system reset.

Solution: The clock can take up to 90 seconds to perform a time set. Delays in the 30 second range are typical. Following a system reset, the clock will be busy for about 10 seconds. During these intervals, the clock will not accept any new instructions. You can get a timeout error if you access the clock when it is busy and your timeout interval is not long enough. You can avoid this problem by setting an appropriate timeout interval or by refraining from sending the clock instructions immediately after a time set or reset.

Problem (Option 100): A unit defined to an input port does not count when activated.

Solution: Be sure that the appropriate input line is grounded. The default state of an unconnected input line is "OFF".

Problem (Option 100): A unit is properly assigned to an output port and activated, but the pulse on the output line is very weak or nonexistent.

Solution: The output lines are connected to open-collector buffers. Check the drive requirements of your receiver circuit and your use of pull-up resistors. High impedance loads like CMOS and ground referenced loads like RTL must have a pull-up to go high. Even though an open TTL input will float high, the use of a pull-up greatly reduces noise problems. Also, the clock output lines will not source any current. Current can be sourced by the pull-up resistor in some case. However, loads demanding high source current, like power transistors, should not be driven directly by the output lines of the Real Time Clock.

Problem: You have written a program for the clock, and you think you are doing the right thing. However, the clock just isn't working properly. Because you are somewhat inexperienced with this new device, you are confused about what to do next.

Solution: Read the 98035A Installation and Operation manual. The Real Time Clock is more complex than its physical size might indicate. It has many subtleties that are not covered in this Programming Techniques manual. If the clock is really not performing as it should, contact the HP Sales and Service Office nearest you.

NOTES



Selected High-Precision Metric Conversion Factors

English Units	Metric Units	To convert from English to Metric, multiply by:	To convert from Metric to English, multiply by:
Length			
mil	micrometre (micron)	2.54×10^{1}☆	$3.937\ 007\ 874 \times 10^{-2}$
inch	millimetre	2.54×10^{1}☆	$3.937\ 007\ 874 \times 10^{-2}$
foot	metre †	3.048×10^{-1}☆	$3.280\ 839\ 895$
mile (intl.)	kilometre	$1.609\ 344$☆	$6.213\ 711\ 922 \times 10^{-1}$
Area			
$inch^2$	$millimetre^2$	$6.451\ 6 \times 10^{2}$☆	$1.550\ 003\ 100 \times 10^{-3}$
$foot^2$	$metre^2$	$9.290\ 304 \times 10^{-2}$☆	$1.076\ 391\ 042 \times 10^{1}$
$mile^2$	$kilometre^2$	$2.589\ 988\ 110$	$3.861\ 021\ 585 \times 10^{-1}$
acre (U.S. survey)	hectare	$4.046\ 873 \times 10^{-1}$	$2.471\ 044$
Volume			
$inches^3$	$millimetres^3$	$1.638\ 706\ 4 \times 10^{4}$☆	$6.102\ 374\ 409 \times 10^{-5}$
$feet^3$	$metres^3$	$2.831\ 684\ 659 \times 10^{-2}$	$3.531\ 466\ 672 \times 10^{1}$
ounces (U.S. fluid)	$centimetres^3$	$2.957\ 353 \times 10^{1}$	$3.381\ 402 \times 10^{-2}$
gallon (U.S. fluid)	litre ‡	$3.785\ 412$	$2.641\ 721 \times 10^{-1}$
Mass			
pound (avdp.)	kilogram	$4.535\ 923\ 7 \times 10^{-1}$☆	$2.204\ 622\ 622$
ton (short)	ton (metric)	$9.071\ 847\ 4 \times 10^{-1}$☆	$1.102\ 311\ 311$
Force			
ounce (force)	dyne	$2.780\ 138\ 510 \times 10^{4}$	$3.596\ 943\ 090 \times 10^{-5}$
pound (force)	newton	$4.448\ 221\ 615$	$2.248\ 089\ 431 \times 10^{-1}$
Pressure			
psi	pascal	$6.894\ 757\ 293 \times 10^{3}$	$1.450\ 377\ 377 \times 10^{-4}$
inches of Hg (at 32°F)	millibar	$3.386\ 4 \times 10^{1}$	$2.952\ 9 \times 10^{-2}$
Energy			
BTU (IST)	Calorie (kg, thermochem.)	$2.521\ 644\ 007 \times 10^{-1}$	$3.965\ 666\ 831$
BTU (IST)	watt-hour	$2.930\ 710\ 702 \times 10^{-1}$	$3.412\ 141\ 633$
BTU (IST)	joule §	$1.055\ 055\ 853 \times 10^{3}$	$9.478\ 171\ 203 \times 10^{-4}$
ft•lb	joule	$1.355\ 817\ 948$	$7.375\ 621\ 493 \times 10^{-1}$
Power			
BTU (IST)/hr	watt	$2.930\ 710\ 702 \times 10^{-1}$	$3.412\ 141\ 633$
horsepower (mechanical)	watt	$7.456\ 998\ 716 \times 10^{2}$	$1.341\ 022\ 090 \times 10^{-3}$
horsepower (electric)	watt	7.46×10^{2}☆	$1.340\ 482\ 574 \times 10^{-3}$
ft•lb/s	watt	$1.355\ 817\ 948$	$7.375\ 621\ 493 \times 10^{-1}$
Temperature			
°Rankine	kelvin	1.8☆	$5.555\ 555\ 556 \times 10^{-1}$
°Fahrenheit	°Celsius	°C=(°F−32) /1.8☆	°F = (°C x 1.8)+32☆

☆ Exact conversion
† Conversion redefined in 1959
‡ Conversion redefined in 1964
§ Conversion redefined in 1956

Note: The preferred metric unit for force is the newton; for pressure, the pascal; and for energy, the joule.

Prefix	Symbol	Multiplier
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deka	da	10^{1}

Prefix	Symbol	Multiplier
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}

Sources

American Society for Testing and Materials (ASTM), "Standard for Metric Practice". Reprinted from Annual Book of ASTM Standards.

U.S. Department of Commerce, National Bureau of Standards, "NBS Guidelines for the Use of the Metric System". Reprinted from Dimensions/NBS. (October 1977).

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